5.0 Channel Status

Channel conveyance capacity can be reduced by a number of factors. These factors can be the result of conditions in the channel, such as vegetation growth in the channel, sediment deposited in the channel, encroachments in the channel, bank erosion, revetments, and bank caving. Levee conditions such as lack of freeboard due to localized settlement, erosion, or original levee design can also reduce channel conveyance capacity. Consequently, identifying the causes of channel conveyance problems (and whether they are channel-related or levee-related) often requires additional site-specific investigation that is beyond the scope of this FCSSR. Furthermore, the conveyance capacity of the system is dynamic and therefore needs to be reevaluated at regular intervals.

Estimates of DWR channel conveyance capacity, as presented in this FCSSR, are not based on the same approach as USACE channel conveyance capacity estimates. DWR uses freeboard as an index point to estimate conveyance capacity, expressed as a flow value. USACE uses a risk-based or probabilistic approach to estimate conveyance capacity. While a risk-based approach provides a better indicator of flood risk, this approach has not been used to define performance expectations for SPFC channels. A risk-based approach can sometimes be impractical to use because of limited geotechnical data and dependence of the approach on the hydrological record, which changes dynamically based on new flood events.

This section summarizes channel conveyance capacity conditions, and then discusses channel vegetation and channel sedimentation as two key factors affecting channel conveyance capacity. Other factors that could reduce channel conveyance capacity (such as encroachments in the channel) were not evaluated because supporting data were not available.

5.1 Channel Conveyance Capacity

SPFC channel conveyance capacity has been estimated based on the ability of a channel to pass original design flood flows. Design flood flows (or design channel capacities) from different official sources have been sometimes inconsistent. These discrepancies have complicated the evaluation of channel conveyance capacities throughout the Sacramento and San Joaquin river watersheds.

The basis for evaluating channel conveyance capacity in the Sacramento River watershed was refined several times after the Flood Control Act of 1917. Design flows were later amended by the Flood Control Act of 1928, Senate Document Number 23, the 1953 Memorandum of Understanding between USACE and the Board (USACE and Board, 1953), and the 1957 design profile for the Sacramento River (USACE, 1957a). The profile and associated design capacities were developed based on USACE analysis of the 1937, 1951, and 1955 floods on the Sacramento River at the request of the Board.

In the San Joaquin River watershed (excluding the Mormon Slough Project), original design flows were derived from the *Report on Control of Floods, San Joaquin River and Tributaries Between Friant Dam and Merced River* (DWR, 1954) and later changed to reflect the 1955 design profile for the San Joaquin River, as shown in *Design Memorandum No. 1, San Joaquin River Levees, Lower San Joaquin River and Tributaries Project* (1955 design profile) (USACE, 1955b). For SPFC channels in the Mormon Slough Project, design capacities were based on the 1965 design profile (USACE, 1965).

All design profiles for the SPFC are included on the reference DVD of the *State Plan of Flood Control Descriptive Document* (DWR, 2010a), or can be viewed on the Board Web site (Board, 2011). For channels not delineated in the 1955, 1957, or 1965 design profiles above, design capacities were determined based on as-constructed capacities specified in appendices to O&M manuals provided by USACE.

Design channel capacities were calculated from the design profiles based on steady-state, uniform flow hydraulic computations of historical floods using data available at the time. Therefore, design channel capacities were based on a very limited hydrological record, were highly dependent on the boundary conditions assumed, and did not consider variations in flow and depth with respect to time and distance. Furthermore, the design profiles could not account for changes in vegetation and sedimentation patterns within the channels, or flood system improvements that have taken place after the historical floods used to derive the design flood flow capacities. For example, the 1955 historical flood used to determine the 1955 design profile for the San Joaquin River downstream from the Merced River confluence occurred before construction of the San Joaquin River bypass system.

Design channel capacities reported in USACE O&M manuals sometimes do not agree with channel capacities associated with design profiles. This is because USACE created some O&M manuals before the design profiles were adopted. DWR operates and maintains SPFC facilities based on

design capacities calculated from the design profiles when available, rather than on design capacities included in the USACE O&M manuals (USACE, 1969). Design channel capacities from both the design profiles and O&M manuals are used as the basis for evaluation of channel conveyance capacities in this FCSSR.

5.1.1 Status Evaluation Methodology

Channel conveyance capacity conditions are evaluated in this FCSSR by comparing estimated existing capacities with design channel capacities specified in O&M manuals and design profiles provided by USACE for each SPFC channel.

Existing capacities were estimated for 1,016 miles of about 2,600 miles of SPFC channels using data from the *State Plan of Flood Control Existing Channel Capacity Assessment Technical Memorandum* (CVFED, 2009) and project-specific modeling results. Existing channel capacities were determined to be the lowest flow rate that occurs when the water surface encroaches on a levee low point (on either the left bank or right bank) minus the design freeboard height. It was assumed that when the water surface encroaches on freeboard at a single location, the capacity of the entire reach is compromised.

The 2009 State Plan of Flood Control Existing Channel Capacity Assessment was conducted by the DWR Central Valley Floodplain Evaluation and Delineation Program. The assessment of existing channel capacities was based strictly on analysis of available information. No direct geotechnical analyses, levee stability investigations, or new hydraulic modeling were conducted. Most of the existing channel capacity information was developed from channel capacity profiles prepared in support of the Comprehensive Study (USACE and DWR, 2002). When available, existing channel capacities from the *State Plan of Flood Control Existing Channel Capacity Assessment Technical Memorandum* (CVFED, 2009) were replaced with more recent project-specific modeling of individual reaches. Project-specific modeling results were provided by the DWR maintenance program or project-level hydraulic studies. The data source for each existing channel capacity is listed by reach in Appendix B, Tables B-1 and B-2.

For the FCSSR, the following criteria were used to determine whether estimated current capacities of the SPFC channels were sufficient to safely convey identified design capacities in the O&M manuals or design capacities calculated from design profiles:

- If the estimate of current capacity was greater than both the design capacity reported in the O&M manual and the design capacity based on

the design profile, channel status was reported as “no obvious inadequacy.”

- If the estimate of current channel capacity was less than the design capacity reported in the O&M manual, or the design capacity based on the design profile (or both), the channel status was reported as “potential inadequacy; additional evaluation required.”

- If the estimate of current channel capacity for a reach depends on backwater flow assumptions, channel status was reported as "backwater controlled; additional evaluation required."

5.1.2 Limitations of Status Evaluations

Accuracy of the existing channel capacity estimates in this report was limited by the topographic and hydraulic modeling performed. Project-specific modeling results generally are less uncertain than systemwide modeling results. Uncertainties associated with estimating current channel capacities throughout the system include vertical datum errors, inaccurate levee crown profiles, arbitrary nature of standard freeboard values, limited calibration data, fixed-bed assumption, wind/wave effects, and unaccounted-for local hydrodynamic effects. Also, differing hydraulic modeling assumptions for boundary conditions, freeboard criteria, and top-of-levee elevations likely contribute to conflicting results among hydraulic modeling evaluations and should be resolved with additional evaluation.

Furthermore, estimates of current channel capacities throughout the system using modeling generally characterizes impedance to flow, and are not designed or intended to evaluate subtle changes in the channels as a result of vegetation, sediment deposition, and/or other obstructions in the channel.

Another uncertainty results from identifying levee low points. In many cases, low levee crown elevations for only a mile or so constrained the capacity of reaches as long as 30 miles. Project-specific modeling of individual reaches could demonstrate that the channel conveyance capacity at one location in a reach is not representative of the entire reach.

Because of these uncertainties, data included in this FCSSR cannot conclusively identify locations of channel conveyance capacity inadequacies, but instead the data identify potential inadequacies requiring additional evaluation.

5.1.3 Results of Status Evaluations

Differences between design capacities reported in O&M manuals and flows associated with the design profiles shown in Figures 5-1 and 5-2 demonstrate the need to resolve discrepancies in some locations. Potential inadequate channel conveyance capacities are shown in Figures 5-3 and 5-4.

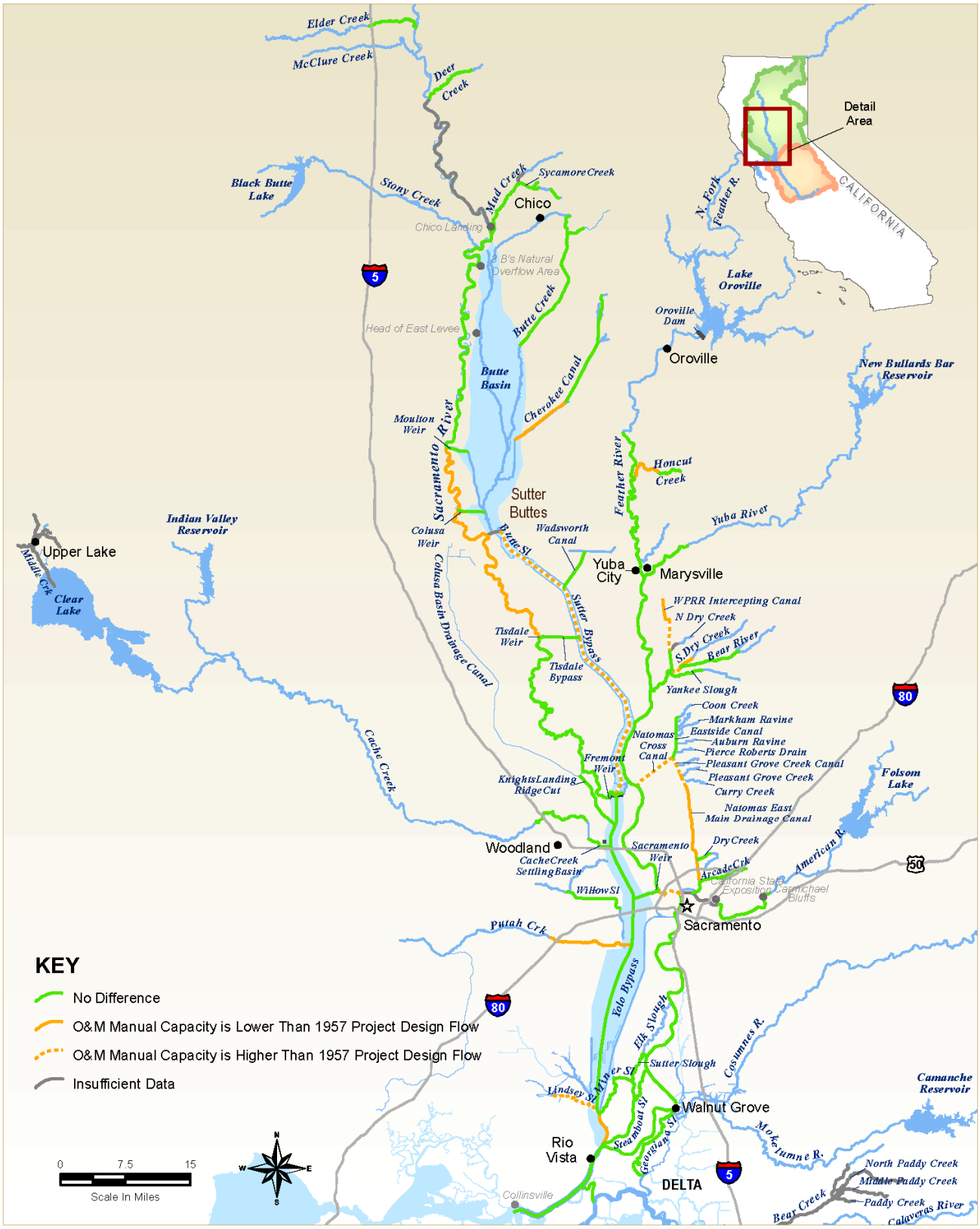

Figure 5-1. Differences Between O&M Manual Design Capacities and Design Profile Flows in Sacramento River Watershed

Figure 5-2. Differences Between O&M Manual Design Capacities and Design Profile Flows in San Joaquin River Watershed

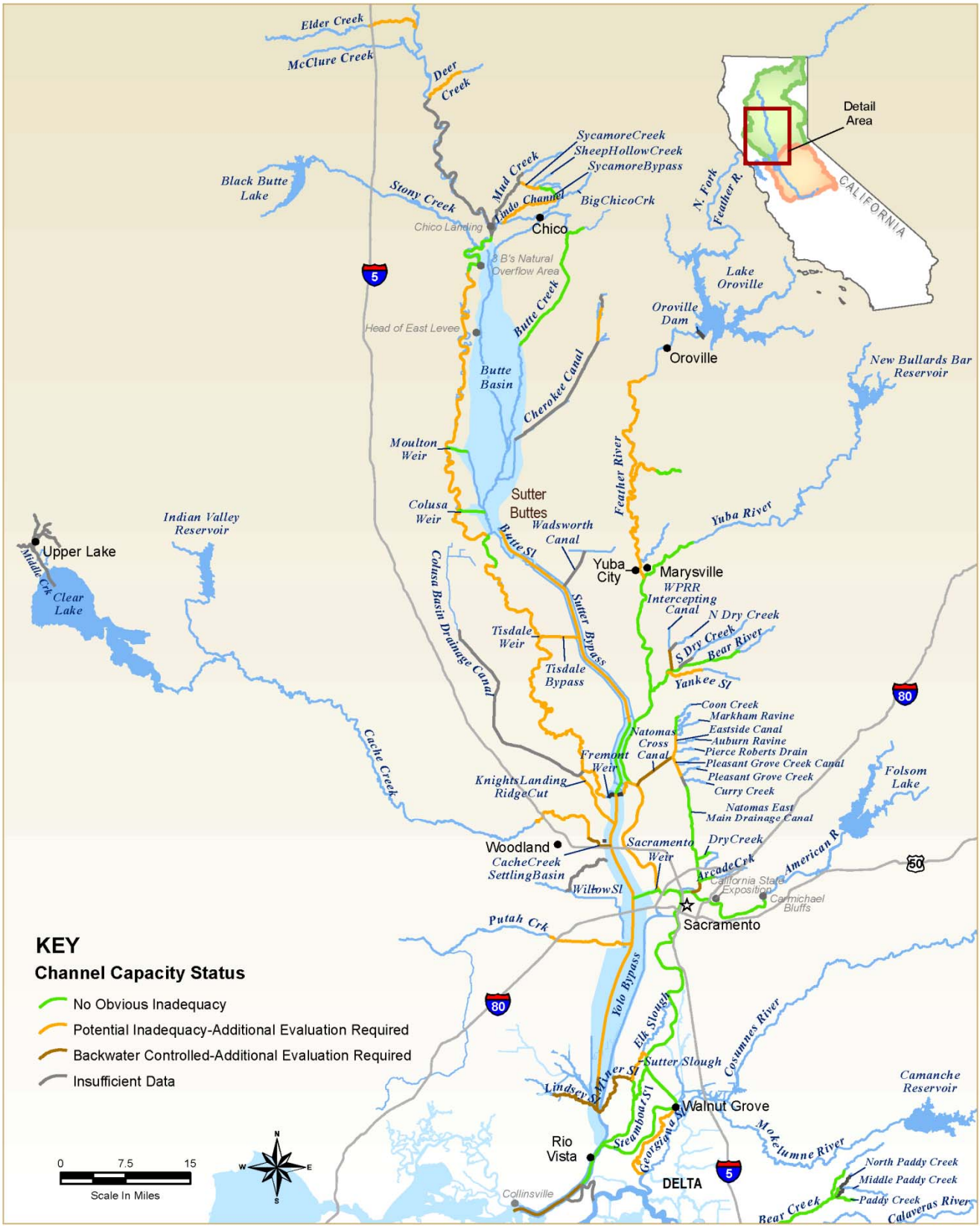

Figure 5-3. Channel Capacity Status in Sacramento River Watershed

Figure 5-4. Channel Capacity Status in San Joaquin River Watershed

For the Sacramento River watershed, approximately four-ninths of the channels show a potential capacity inadequacy and need for additional evaluation, and data are insufficient for approximately one-fifth of the channels. In general, approximately three-fifths of the channels in the San Joaquin River watershed show a potential capacity inadequacy and need for additional evaluation, and data are insufficient for one-eighth. These results will be refined as systemwide and project-specific hydraulic modeling efforts progress. Appendix B, Section B-1, contains tables of the results shown in Figures 5-3 and 5-4.

For additional information on recent, ongoing, and planned remedial actions/improvements, and ongoing actions to improve future evaluations, see Appendix B, Section B-2.

5.2 Channel Vegetation

Criteria for vegetation management in the channels have been evolving since SPFC facilities were constructed. Maintenance criteria are contained in standard and unit-specific O&M manuals provided by USACE, Title 23 of the California Code of Regulations, and Title 33 of the Code of Federal Regulations.

State and federal environmental laws have complicated efforts to maintain SPFC channels. These environmental laws include the State and federal Endangered Species Acts; federal Clean Water Act, federal Porter-Cologne Act and Migratory Bird Treaty Act; and California Fish and Game Code requirements for Stream Bed Alteration Agreements. Specifically, channel maintenance is increasingly challenging because of compliance requirements for these laws and regulations, and the length of time for obtaining approvals for maintenance.

Table 5-1 lists current standards that apply to vegetation management for channels. (Note that standards that apply to vegetation management for levees are discussed in Section 4.7.)

Table 5-1. Current Standards for Channel Vegetation Management

Source of Standard	General Description of Standard
Title 33, Federal Statutes, Part 208	Provides some flexibility in allowing vegetation in a channel as long as project works function properly and are not impaired by debris, weeds, or wild growth.
Title 23, CCR	Vegetation that impedes or misdirects floodflows is not permitted to remain within a floodway or bypass.[1]
General and unit-specific O&M manuals	Generally requires that "the channel or floodway is clear of debris, weeds and wild growth."[2] Limits vegetation in a project flood control channel to nondense brush or trees not more than 2 inches in diameter. Vegetation in channel is allowed if the design water surface profile is maintained.
USACE Sacramento District correspondence[3]	Allowable vegetation in a floodway shall not affect the capability of the project works to convey design flows within specified levels of freeboard, and shall not compromise the integrity or inspectability of the flood control project. In addition, channels shall pass design flows at stage levels at or below the 1957 design profile.[4] Projects containing significant vegetation within a channel will be considered in compliance when the sponsor shows, through hydraulic analysis, that the project is capable of conveying design flows while maintaining the specified levels of freeboard.
Clean Water Act Section 404	Vegetation management activities could require that a Clean Water Act Section 404 permit be obtained from USACE for discharge of dredged or fill material into "waters of the United States, including wetlands." Waters of the United States include traditionally navigable rivers and their tributaries, and adjacent wetlands that have a significant nexus with waters of the United States. If a Section 404 permit is required, a Clean Water Act Section 401 Water Quality Certification would also be required by the Regional Water Quality Control Board.
Federal Endangered Species Act	Vegetation management activities could potentially adversely impact fish and wildlife species and their habitat. Section 7 of the Endangered Species Act outlines procedures for federal interagency cooperation for implementing the Endangered Species Act. Section 7(a)(2) requires that federal agencies consult with USFWS and/or NMFS so that "any action authorized, funded, or carried out by such agency" does not jeopardize the existence of a listed species or adversely modify critical habitat. If there is no federal nexus, a Habitat Conservation Plan or low-threat Habitat Conservation Plan may need to be prepared and complied with.
California Endangered Species Act	Vegetation management activities could potentially adversely impact fish and wildlife species and their habitat. Pursuant to the California Endangered Species Act, a permit from the California DFG is required for projects that could result in the "take" of a plant or animal species that is State-listed as threatened or endangered, or is a candidate species. In accordance with Sections 2080 and 2081 of the California Fish and Game Code, a Consistency Determination or Incidental Take Permit could be required.
California Fish and Game Code Section 1600, Streambed Alteration Agreement	Because vegetation management activities conducted in channels could potentially change the bed, channel, or bank of a channel, and potentially adversely impact fish and wildlife species and their habitat, a California Fish and Game Code Section 1600 Streambed Alteration Agreement may be needed (DFG, 2010).
DWR Interim Levee Vegetation Inspection Criteria	Interim Levee Vegetation Inspection Criteria that also affect vegetation in channels (DWR, 2007).

Table 5-1. Current Standards for Channel Vegetation Management (contd.)

Source of Standard	General Description of Standard
Central Valley Flood System Improvement Framework—Interim Criteria for Vegetation Management	Interim Criteria for Vegetation Management (until adoption of CVFPP) (California Levees Roundtable, 2009).

Notes:
[1] Title 23, California Code of Regulations, Section 131.
[2] Standard O&M Manual for the Sacramento River Flood Control Project, revised May 1955, USACE Sacramento District. (USACE, 1955a).
[3] USACE correspondence dated August 14, 2006, regarding The Reclamation Board's request for clarification of the State's O&M responsibilities associated with federal projects for which The Reclamation Board provided assurances of cooperation.
[4] USACE *Levee and Channel Profiles, File Number 50-10-334.*

Key:
CCR = California Code of Regulations
CVFPP = Central Valley Flood Protection Plan
DFG = California Department of Fish and Game
DWR = California Department of Water Resources
NMFS = National Marine Fisheries Service
O&M = operations and maintenance
USACE = U.S. Army Corps of Engineers
USFWS = U.S. Fish and Wildlife Service

5.2.1 Status Evaluation Methodology

Channel vegetation conditions are evaluated by the degree to which vegetation impedes flood flows. Vegetation management conditions were evaluated against DWR's current maintenance standards using results of annual inspections in 2009. DWR visually inspects 26 channels identified as SPFC channels at least twice a year, in addition to visually inspecting channels adjacent to SPFC levees at least twice a year at the same time the levees are inspected. Table 5-2 contains rating descriptions for channel vegetation. Each channel inspection location includes a separate upstream and downstream channel inspection rating. In this FCSSR, only the worst of the two ratings is reported for each location.

Table 5-2. Channel Inspection Rating Descriptions for Channel Vegetation

Inspection Rating	Rating Description
Acceptable (A)	Minimal, scattered obstructions or vegetation. Flow is not impeded.
Minimally Acceptable (M)	Log jams, snags, vegetation growth (such as cattails, bullrushes, bushes, or saplings), or other obstructions block approximately 25 percent of the flood control work.
Unacceptable (U)	Log jams, snags, vegetation growth (such as cattails, bullrushes, bushes, or saplings), or other obstructions block approximately 50 percent of the flood control work.

5.2.2 Limitations of Status Results

Information on channel vegetation management conditions is limited to the channels that DWR inspects (26 channels and 186 total miles) and to

conditions that are visible. Channel vegetation inspections are usually performed from selected points along a channel and from the crown of a levee. Impacts of vegetation on channel conveyance can be evaluated more thoroughly using the following methods: past performance evaluation, vegetation surveying, and project-specific hydraulic modeling.

To comply with USACE guidance, DWR must demonstrate that vegetation in a channel does not impact channel conveyance capacity and does not encroach on the freeboard. Clarification is often needed on the specified levels of freeboard used to determine the extent of allowable vegetation throughout a channel. Inconsistencies on the required level of freeboard are common among SPFC channels: the freeboard cited in O&M manuals often conflicts with the freeboard specified in as-constructed plans. Determining the required levels of freeboard is therefore critical in assessing conveyance capacity, and whether vegetation or other factors are impeding proper functioning of SPFC facilities.

5.2.3 Results of Status Evaluations

Channel inspection ratings for vegetation from the *2009 Inspection Report of the Central Valley State-Federal Flood Protection System* (DWR, 2010b) are shown in Figures 5-5 and 5-6 for channels maintained by DWR and other maintaining agencies. Of the 186 miles of SPFC channels inspected by DWR, one location was rated Unacceptable (Berenda Slough, downstream from Avenue 21) and 54 locations were rated Minimally Acceptable for channel vegetation. Additional vegetation problems may be present in channels not inspected by DWR.

Areas that are undergoing active vegetation management, or in which vegetation management has been initiated or required in the Sacramento River watershed, are shown in Figure B-5 in Appendix B, Section B-2. Similar data were unavailable for the San Joaquin River watershed. For additional information on recent remedial actions/improvements, ongoing and planned remedial actions/improvements, and ongoing actions to improve future evaluations of vegetation management in channels, see Appendix B, Section B-2.

Figure 5-5. 2009 Channel Vegetation Inspection Ratings in Sacramento River Watershed

Figure 5-6. 2009 Channel Vegetation Inspection Ratings in San Joaquin River Watershed

5.3 Channel Sedimentation

Since SPFC facilities were constructed, maintenance standards have been consistent in requiring actions to address shoaling or sedimentation that reduces channel conveyance capacity or deflects flows within a channel. Channel sedimentation can occur in areas of significant flow expansion (i.e., bypass inlets), in backwater near confluences, or in some tidally influenced reaches. In addition to reducing channel conveyance capacity, channel sedimentation of natural channels can cause lateral redirection of flows, leading to bank erosion. (In cases where design channel capacity is not impaired, such flow redirection problems caused by sedimentation can be addressed by sediment redistribution within the channel, instead of more expensive sediment removal and disposal.)

Sedimentation can also induce vegetation encroachment when low-flow conditions prevent the natural removal of vegetation on bars that are formed along a channel. Several areas with known sedimentation problems, such as the Cherokee Canal and Yuba River, are associated with hydraulic mining debris from the nineteenth century. Sedimentation also often results from eroding riverbanks and levees and agricultural runoff.

Table 5-3 lists current standards that apply to sediment management for channels.

Table 5-3. Current Standards for Channel Sediment Management

Source of Standard	Description of Standard
Title 33, Federal Statutes, part 208	Sediment management is to be performed in channels so that flood conveyance capacity is maintained.
Federal Clean Water Act Section 404	Channel sedimentation management activities could require a Clean Water Act Section 404 permit to be obtained from USACE for discharge of dredged or fill material into “waters of the United States, including wetlands.” Waters of the United States include traditionally navigable rivers and their tributaries and adjacent wetlands that have a significant nexus with waters of the United States. If a Section 404 permit is required, a Clean Water Act Section 401 Water Quality Certification would also be required by the Regional Water Quality Control Board.
Federal Rivers and Harbors Act	The River and Harbors Act of 1899 addresses activities that involve the construction of, among other structures, dams, bridges, and dikes across any navigable water. The act also addresses placement of obstructions to navigation outside established federal lines, as well as the excavation or deposition of material in such waters. All of these actions require permits from USACE.
Unit-specific O&M manuals	Generally, limit sedimentation in a project flood protection system so that “the capacity of the channel or floodway is not being reduced by the formation of shoals.”

Table 5-3. Current Standards for Channel Sediment Management (contd.)

Source of Standard	Description of Standard
Engineer Technical Letter 1110-2-571	Provides some flexibility to sediment management if the water surface profile is maintained. The operative rule is that "capacity of the channel or floodway is not being restricted by the formation of shoals" (USACE, 2009b).
Standard O&M Manual for the Sacramento River Flood Control Project	States that "the capacity of the channel or floodway is not being reduced by the formation of shoals" and "sediment, rubbish, industrial waste or any debris plugs or other obstructions should be removed from the channel to prevent any tendency for the flows to be deflected within the channel" (USACE, 1955a)

Key:
O&M = operations and maintenance
USACE = U.S. Army Corps of Engineers

5.3.1 Status Evaluation Methodology

Sediment management conditions were evaluated against DWR's current maintenance standards using results of the *2009 Inspection Report of the Central Valley State-Federal Flood Protection System* (DWR, 2010b). Table 5-4 shows DWR inspection rating descriptions for shoaling and sedimentation in SPFC channels. Each channel inspection location includes a separate upstream and downstream channel inspection rating. In this FCSSR, only the worst of the two ratings is reported for each location.

Table 5-4. Channel Inspection Rating Descriptions for Shoaling and Sedimentation

Inspection Rating	Rating Description
Acceptable (A)	No shoaling or sedimentation present.
Minimally Acceptable (M)	Nonaquatic grasses present on shoal. No trees or brush are present on shoal, and channel flow is not impeded.
Unacceptable (U)	Shoaling is well established, and stabilized by trees, brush, or other vegetation. Shoals are diverting flow to channel bank causing bank erosion and undercutting.

5.3.2 Limitations of Status Evaluations

Information on channel sedimentation conditions is limited to the channels that DWR inspects (26 channels and 186 miles) and to conditions that are visible. Shoaling and sedimentation inspections are usually performed from selected points along a channel and from the crown of a levee. Sedimentation conditions can be evaluated more thoroughly using the following methods: observation, past performance evaluation, channel surveying, and project-specific hydraulic modeling. Using these methods,

a channel is determined to be inadequate if the channel capacity is less than the design capacity. Data on lowering of channel beds, bank instability, and channel widening are not available.

5.3.3 Results of Status Evaluations

Shoaling and sedimentation channel inspection ratings from the *2009 Inspection Report of the Central Valley State-Federal Flood Protection System* (DWR, 2010b) are shown in Figures 5-7 and 5-8. Of the 186 miles of SPFC channels inspected by DWR, one location was rated Unacceptable (Berenda Slough, downstream and upstream from Avenue 21) and 23 locations were rated Minimally Acceptable for shoaling and sedimentation. Additional channel sedimentation problems may exist in areas not inspected by DWR.

Figure B-6 in Appendix B, Section B-3, shows the current status of sediment management projects in channels that DWR is responsible for maintaining in the Sacramento River watershed. Graphs embedded in Figure B-6 show annual cubic yards of sediment removed by DWR from 1983 through 2009. Data for sediment management activities in the San Joaquin River watershed are currently not available.

For additional information on recent remedial actions/improvements, ongoing and planned remedial actions/improvements, and ongoing actions to improve future evaluations of sedimentation in SPFC channels, see Appendix B, Section B-3.

Figure 5-7. 2009 Channel Shoaling/Sedimentation Inspection Ratings in Sacramento River Watershed

Figure 5-8. 2009 Channel Shoaling/Sedimentation Inspection Ratings in San Joaquin River Watershed

6.0 Flood Control Structure Status

The SPFC depends on many flood control structures built along tributaries and bypasses to redirect, restrict, or attenuate floodflows to protect lives and property, including hydraulic structures, pumping plants, and bridges. Although major flood control structures in the Sacramento and San Joaquin river watersheds are part of the SPFC, the flood management system also relies on many non-SPFC hydraulic structures, pumping plants, and bridges to convey floodwaters. Flow in the Sacramento River is reduced by floodwater spilled into bypass areas through five SPFC weirs (Moulton, Colusa, Tisdale, Fremont, and Sacramento). Because of these spills to the bypass areas, the design flow capacity of the Sacramento River generally decreases in a downstream direction except where tributary inflow increases river flow. In the upper San Joaquin River, SPFC hydraulic structures help direct flows into the Chowchilla, Eastside, and Mariposa bypasses.

Some flood control structures are multiuse and are operated during both the flood and nonflood seasons under differing parameters. A few of the structures are mainly used to manage flows during nonflood season. These flood control structures include fixed crest diversion weirs, controllable diversion structures, outfall structures, drop structures, and interior drainage pumping plants. Flood control structures also include the M&T and Goose Lake flood relief structures and bridges that are maintained by DWR to convey floodwaters in accordance with California Water Code Section 8361.

Many flood control structures in the SPFC were designed and constructed before current design criteria were adopted, and have not been upgraded to meet current inspection criteria. These structures were generally built between 1940 and 1970, with several structures constructed even earlier. A few structures were modified or improved in the intervening years, but many of the structures are near or have exceeded the end of their expected service lives. Some flood control structures are visibly aging and have significant age-related damage and other problems, in addition to being functionally obsolete (meaning that they have inadequate controls, lack redundant backup power supply, or have restricted access for maintenance).

DWR's maintenance activities for SPFC flood control structures were the subject of an annual report in 1959, entitled *Location, Description and Inventory of Miscellaneous Project Structures, Sacramento River Flood Control Project, and American River Flood Control Project.* This report

was followed shortly by a maintenance status report. DWR has since provided annual maintenance status reports on flood control structures to the Board.

DWR inspects federal project structures in both the Sacramento and San Joaquin watersheds. Several of these project structures are not part of the SPFC because documentation of State assurances of nonfederal cooperation has not been found, but these structures are included in this section to provide status information. Physical conditions of project flood control structures inspected by DWR in 2009 are summarized below, according to the following categories:

- Hydraulic structures
- Pumping plants
- Bridges

Status information for the M&T and Goose Lake flood relief structures is not included because they were not inspected in 2009.

6.1 Hydraulic Structures

SPFC hydraulic structures include weirs, drop structures, control structures, drainage structures, and outfall structures. DWR has historically conducted visual inspections and documented conditions of SPFC hydraulic structures (but not to evaluate their structural integrity). DWR inspection criteria have evolved as USACE has updated design guidance. The most significant recent change in DWR inspection criteria is the emphasis on structural integrity (overall condition of the structures) and the functionality of hydraulic structures (such as availability of redundant backup power supply).

DWR has expanded its current inspection program to evaluate overall conditions of the hydraulic structures it maintains. Because the hydraulic structures maintained by DWR are the oldest in the system and are near or have exceeded their expected service lives, DWR is now evaluating these structures to determine their future serviceability. Furthermore, DWR is working with USACE and maintaining agencies to evaluate other hydraulic structures and, if necessary, reconstruct them with USACE to meet federal standards.

6.1.1 Status Evaluation Methodology

Annual inspections for hydraulic structures form the basis for this evaluation, as presented in the DWR *2009 Inspection Report of the Central*

Valley State-Federal Flood Protection System (2010b*)*. In addition, 2009 inspection results from the DWR Hydraulic Structures Inspection Program were incorporated into the evaluation, as appropriate (see Section 2.1 for details on the two inspection programs). Thirty-two SPFC hydraulic structures and twelve non-SPFC hydraulic structures were inspected. The hydraulic structure inspections rated conditions as Acceptable (A), Minimally Acceptable (M), or Unacceptable (U) based on the following categories: structural condition, vegetation and obstructions, encroachments, and erosion/bank caving and shoaling/sedimentation. These categories are based on the USACE *Flood Damage Reduction Segment/System Inspection Report* (2009a).

Hydraulic structure inspection ratings for structural conditions include a wide variety of inspection categories:

- Closure structures
- Concrete surfaces
- Concrete tilting/settlement
- Concrete foundations
- Culverts: inlets/outlets
- Culverts: breaks/holes/cracks
- Electric gate operators
- Flap gates
- Manual gate operators
- Metal pipes
- Monolith joints
- Other metallic items
- Revetments
- Sluice/slide gates
- Trash racks

Detailed hydraulic structure inspection rating descriptions for structural conditions can be found in the DWR *2009 Inspection Report of the Central Valley State-Federal Flood Protection System* (2010b). Tables 6-1 through 6-3 show DWR inspection rating descriptions of hydraulic structures for vegetation and obstructions conditions, encroachment conditions, and erosion/bank caving and shoaling/sedimentation conditions, respectively.

Table 6-1. Hydraulic Structure Inspection Rating Descriptions for Vegetation and Obstruction Conditions

Inspection Category	Inspection Rating	Rating Description
Vegetation and Obstructions	Acceptable (A)	Minimal, scattered obstructions or vegetation. Flow is not impeded.
	Minimally Acceptable (M)	Log jams, snags, vegetation growth (such as cattails, bullrushes, bushes, or saplings), or other obstructions block approximately 25 percent of the flood control work.
	Unacceptable (U)	Log jams, snags, vegetation growth (such as cattails, bullrushes, bushes, or saplings), or other obstructions block approximately 50 percent of the flood control work.

Table 6-2. Hydraulic Structure Inspection Rating Descriptions for Encroachment Conditions

Inspection Category	Inspection Rating	Rating Description
Encroachments	Acceptable (A)	No trash, debris, excavation, structures, or other obstructions present within the project easement area. Encroachments that do not diminish proper functioning of the project have been previously approved by the Central Valley Flood Protection Board.
	Minimally Acceptable (M)	Trash, debris, excavations, structures, other obstructions present, or inappropriate activities that will not inhibit project operations and maintenance or emergency operations. Encroachments have been approved by the Central Valley Flood Protection Board.
	Unacceptable (U)	Trash, debris, excavations, structures, other obstructions present, or inappropriate activities that will inhibit project operations and maintenance or emergency operations.

Table 6-3. Hydraulic Structure Inspection Rating Descriptions for Erosion/Bank Caving and Shoaling/Sedimentation Conditions

Inspection Category	Inspection Rating	Rating Description
Erosion/Bank Caving	Acceptable (A)	No active erosion or bank caving observed on the landward or riverward side of the levee.
	Minimally Acceptable (M)	Active erosion is occurring in some areas or has occurred on or near the levee embankment, but levee integrity is not threatened.
	Unacceptable (U)	Erosion or caving is occurring or has occurred that threatens the stability and integrity of the levee. The erosion or caving has progressed into the levee section or into the extended footprint of the levee foundation and has compromised the levee foundation stability.
Shoaling/ Sedimentation	Acceptable (A)	No shoaling or sedimentation present.
	Minimally Acceptable (M)	Nonaquatic grasses present on shoal. No trees or brush are present on shoal, and structure operation and channel flows are not impeded.
	Unacceptable (U)	Shoaling is well established, and is stabilized by trees, brush, or other vegetation. Shoals are obstructing structure operation or diverting flow to channel bank, causing bank erosion and undercutting.

6.1.2 Limitations of Status Evaluations

This evaluation covers only hydraulic structures inspected by DWR, and is limited to conditions that can be visually inspected, annually, during the summer. Most hydraulic structures inspected by DWR are part of the SPFC, but there are a few non-SPFC structures inspected as part of federal projects. Status information for other hydraulic structures in the flood management system is not included because it was not available.

6.1.3 Results of Status Evaluations

Hydraulic structure conditions observed during annual inspections in 2009 (DWR, 2010b) are presented in Figures 6-1 through 6-8 for the Sacramento and San Joaquin river watersheds. Tabular results summarizing the Minimally Acceptable and Unacceptable inspection ratings for SPFC and non-SPFC hydraulic structures are shown in Table 6-4.

Ongoing and planned remedial actions and ongoing actions to improve future evaluations are summarized in Appendix C, Section C-1.

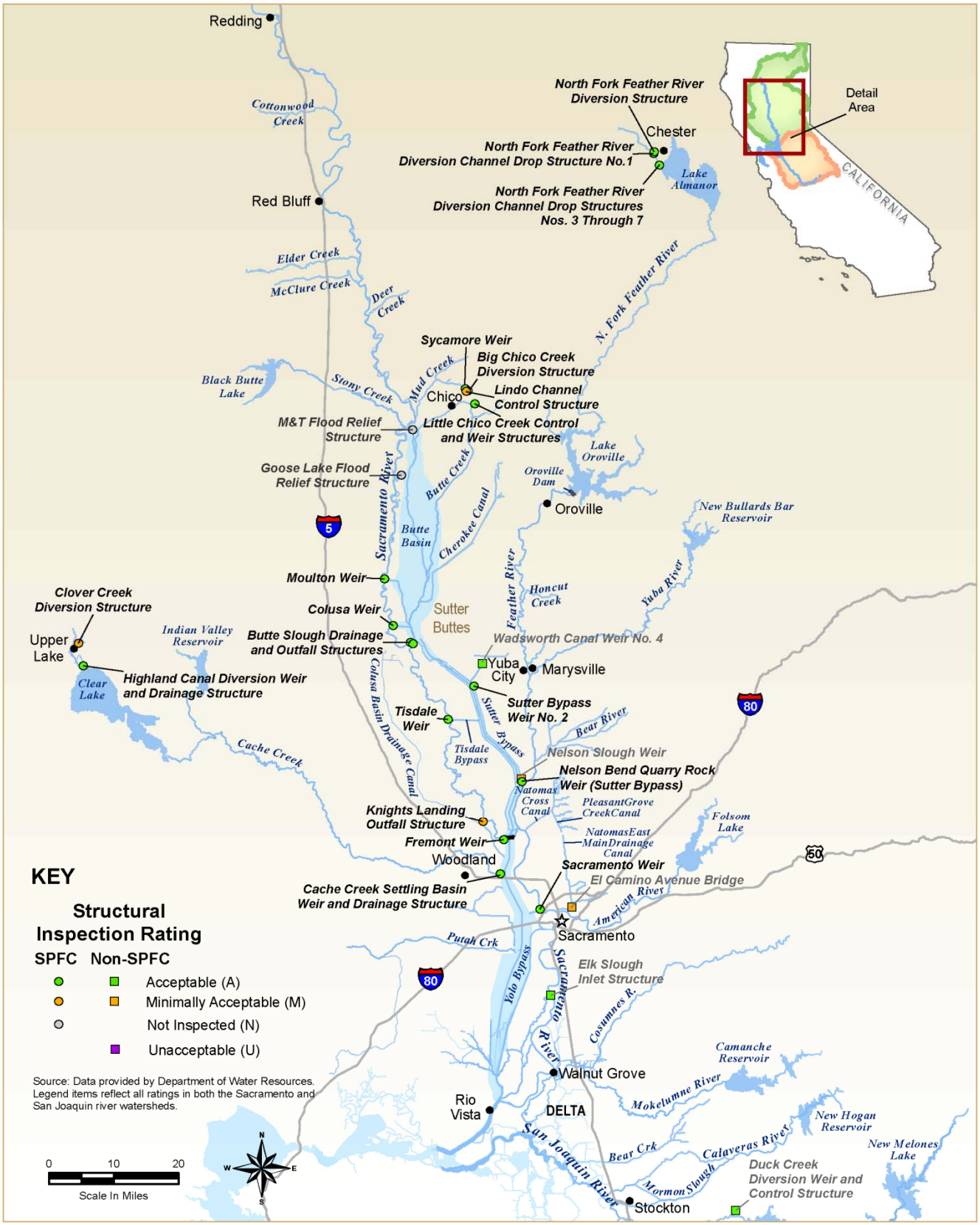

Figure 6-1. Hydraulic Structures – Structural Conditions in Sacramento River Watershed

Figure 6-2. Hydraulic Structures – Structural Conditions in San Joaquin River Watershed

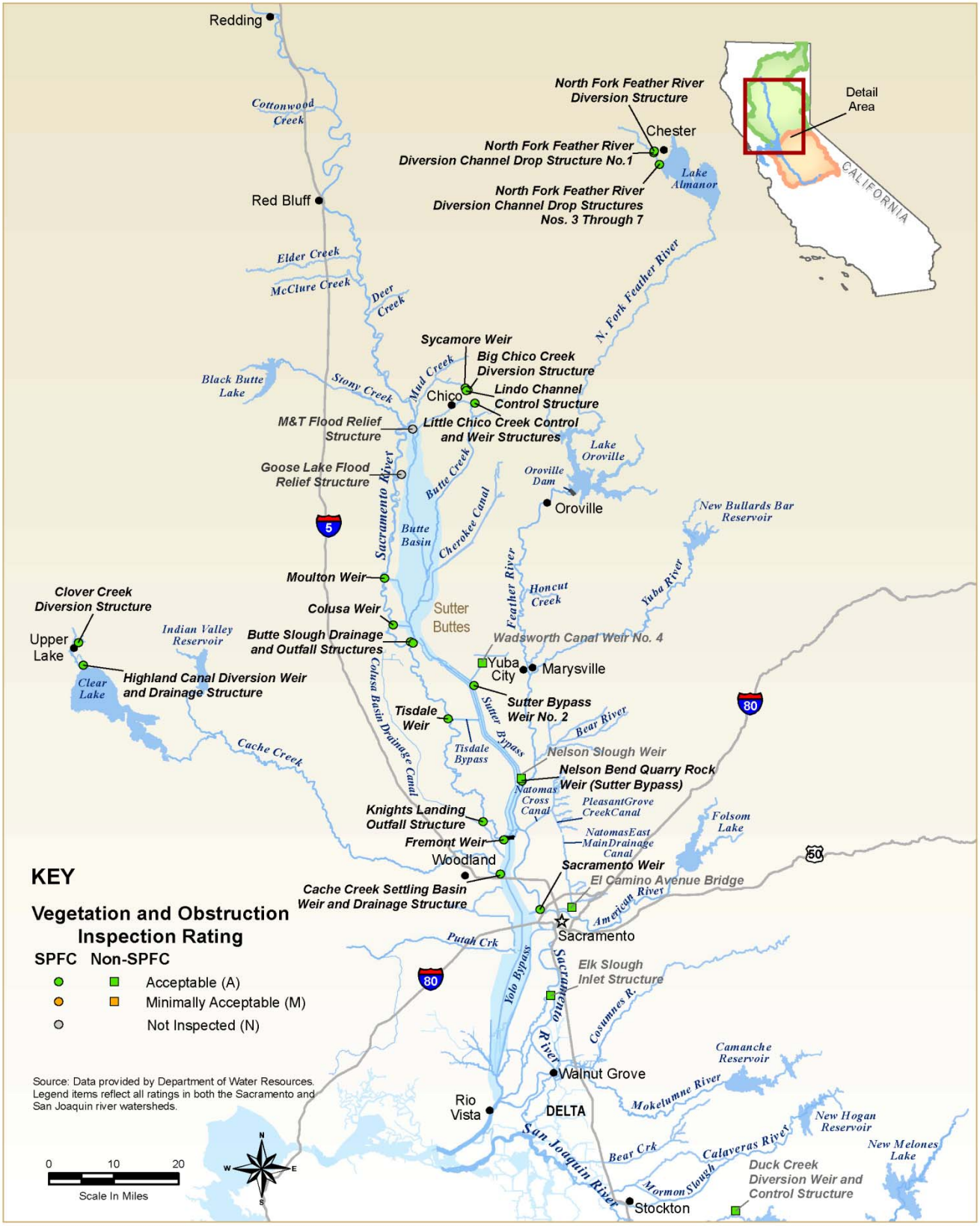

Figure 6-3. Hydraulic Structures – Vegetation and Obstruction Conditions in Sacramento River Watershed

Figure 6-4. Hydraulic Structures – Vegetation and Obstruction Conditions in San Joaquin River Watershed

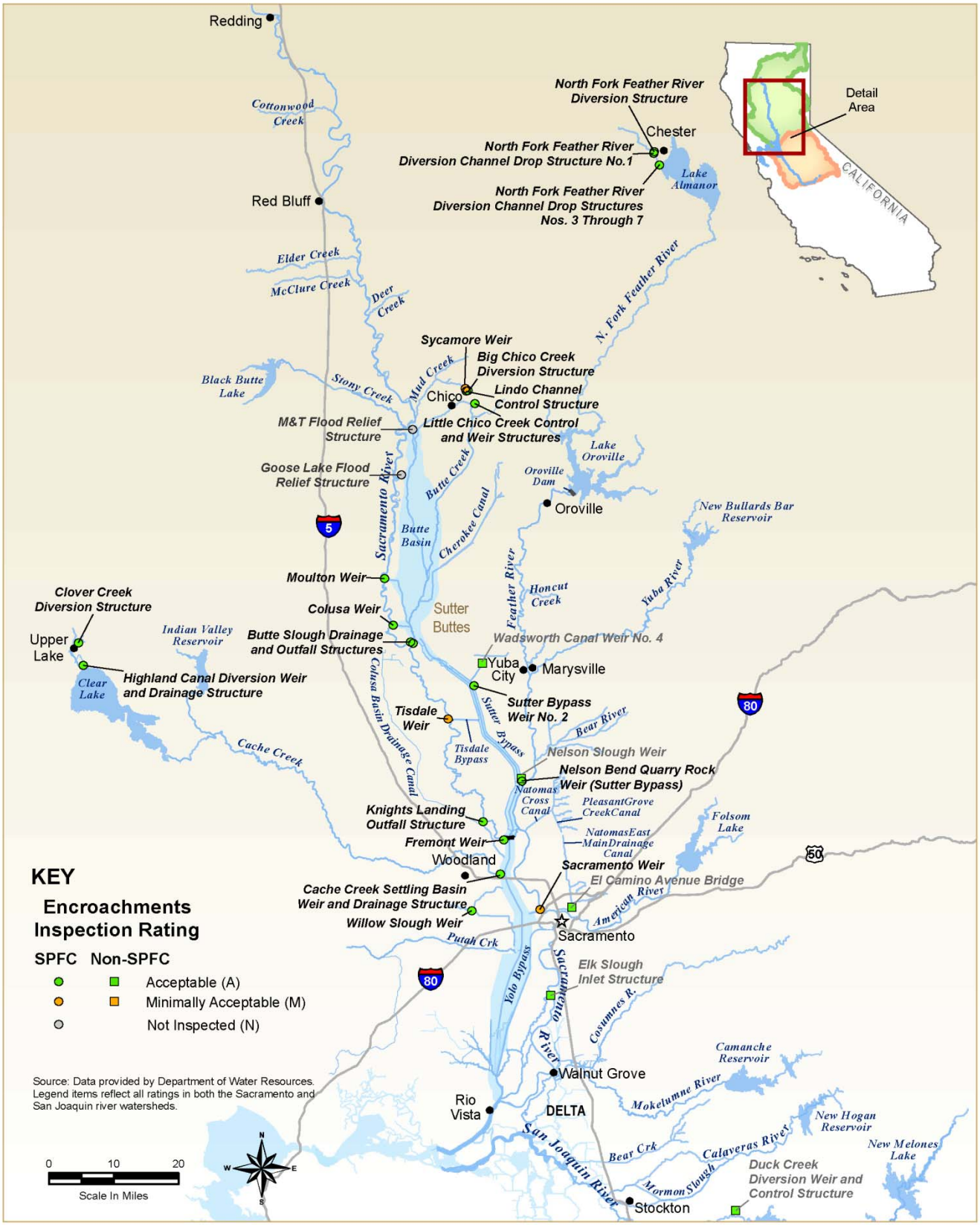

Figure 6-5. Hydraulic Structures – Encroachment Conditions in Sacramento River Watershed

Figure 6-6. Hydraulic Structures – Encroachment Conditions in San Joaquin River Watershed

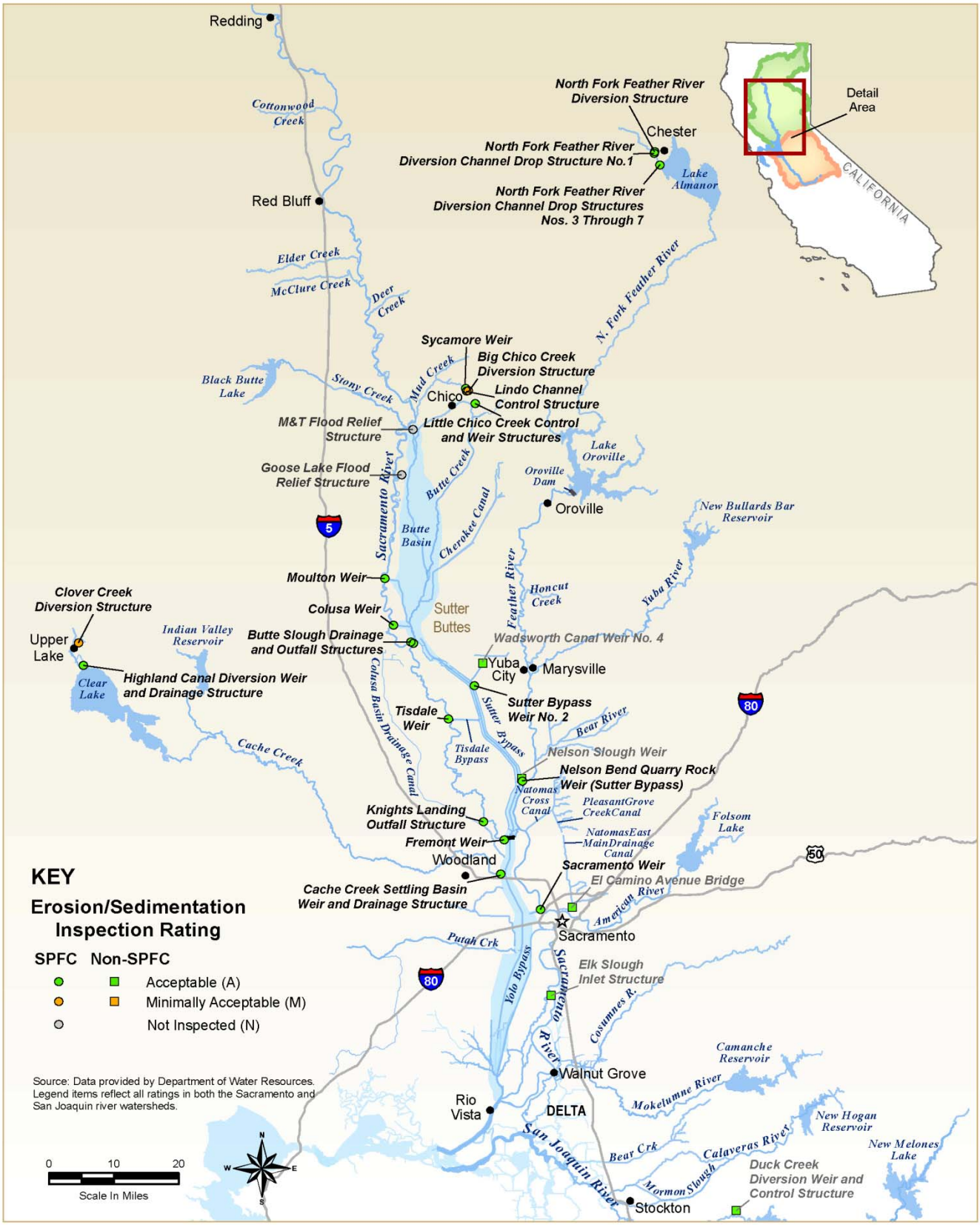

Figure 6-7. Hydraulic Structures – Erosion/Bank Caving and Shoaling/Sedimentation Conditions in Sacramento River Watershed

Figure 6-8. Hydraulic Structures – Erosion/Bank Caving and Shoaling/Sedimentation Conditions in San Joaquin River Watershed

Table 6-4. Hydraulic Structure Conditions Summary (2009)

	SPFC Hydraulic Structures[1]			Non-SPFC Hydraulic Structures[1,2]		
Inspection Category	**Unacceptable**	**Minimally Acceptable**	**Acceptable**	**Unacceptable**	**Minimally Acceptable**	**Acceptable**
Structural	0	5	27	1	5	6
Vegetation/ Obstructions	0	2	30	0	2	10
Encroachment	0	4	28	0	2	10
Erosion/Bank Caving Shoaling/ Sedimentation	0	2	30	0	1	11

Note:
[1] Information is summarized for hydraulic structures inspected by DWR in 2009, only.
[2] Non-SPFC hydraulic structures summarized are inspected by DWR as part of the federal project, but not as part of the SPFC because they lack documentation of assurances of nonfederal cooperation from the Board to USACE.
Key:
SPFC = State Plan of Flood Control

6.2 Pumping Plants

Pumping plants discharge drainage water into adjacent channels to reduce localized flooding. The evolution of criteria and DWR inspections related to pumping plants is the same as described for hydraulic structures in Section 6.1.

6.2.1 Status Evaluation Methodology

Annual inspections for pumping plants are presented in the DWR *2009 Inspection Report of the Central Valley State-Federal Flood Protection System* (2010b). Eleven SPFC pumping plants and two non-SPFC pumping plants were inspected. Pumping plants were rated as Acceptable (A), Minimally Acceptable (M), or Unacceptable (U) based on numerous inspection categories. Table 6-5 shows DWR inspection rating descriptions for pumping plants.

Detailed rating criteria for each inspection category can be found in the DWR *2009 Inspection Report of the Central Valley State-Federal Flood Protection System*, Appendix C (2010b).

Table 6-5. Pumping Plant Inspection Rating Descriptions

Inspection Rating	Rating Description
Acceptable (A)	Weighted calculation of Acceptable, including consideration of operating log, O&M manual, plant building, communications, safety, cranes, pumps, power, motors, engines, fans, gear reducers, pump control systems, sumps/wet well, trash racks, trash rakes, sluice/slide gates, electric gate operators, manual gate operators, other metallic items, flap gates, closure structures, security fencing, intake and discharge pipes, and pressurized pipes.
Minimally Acceptable (M)	Weighted calculation of Minimally Acceptable, including consideration of elements above.
Unacceptable (U)	Weighted calculation of Unacceptable, including consideration of elements above.

Key:
O&M = operations and maintenance

6.2.2 Limitations of Status Evaluations

This evaluation covers only pumping plants inspected by DWR, and is limited to conditions that were visually inspected, annually, during summer. Most pumping plants inspected by DWR are part of the SPFC, but there are two non-SPFC pumping plants inspected as part of federal projects. Status information for other pumping plants in the flood management system is not included because it was not available.

6.2.3 Results of Status Evaluations

Pumping plant conditions from annual inspections in 2009 (DWR, 2009b) are presented in Figure 6-9 for the Sacramento and San Joaquin river watersheds. Of 13 pumping plants inspected, no pumping plants were rated Unacceptable overall; six pumping plants were rated as Minimally Acceptable.

Ongoing and planned remedial actions and ongoing actions to improve future evaluations are summarized in Appendix C, Section C-2.

Figure 6-9. Pumping Plant Conditions in Sacramento and San Joaquin River Watersheds

6.3 Bridges

DWR maintains and inspects some bridges in the Sacramento Watershed in accordance with California Water Code Section 8361 (c), and does not maintain or inspect any bridges in the San Joaquin River watershed. Before 2008, DWR did not conduct a separate annual inspection for bridges, but inspected bridges as components of overall channel inspections for conveyance capacity under the DWR Annual Inspection Program. Many bridges in the SPFC were designed and built before other SPFC facilities were constructed. In most cases, conveyance capacity through bridge openings was incorporated into SPFC levee and channel design. However, in some instances, encroachment into the floodflow capacity caused by bridges was not addressed as part of the design capacity (e.g., a bridge is lower than the design stage and/or levees at the bridge abutment have insufficient freeboard or are below the design stage). Bridges constructed after other SPFC facilities were generally evaluated by USACE and the Board so that bridges would not impact flows and/or impede flood emergency and/or maintenance operations.

6.3.1 Status Evaluation Methodology

DWR evaluated the condition of bridges against current maintenance standards using the results of annual bridge inspections in 2009 through the DWR Bridge Inspection Program. Inspection criteria for DWR's inspection logs were customized to each bridge based on the material used to construct the bridge. Visual inspections were performed on each DWR-maintained bridge regarding safe passage by evaluating the following: foundation scour, abutment erosion, approach grades, and overall structural integrity. Concrete bridges were inspected for cracks, chips, spalling, joint separation, and exposed rebar. Wooden structures were inspected for deterioration, cracking, joint and fastener separation, and wear. Inspection rating descriptions for bridges are listed in Table 6-6, with inspection elements listed above categorized for bridge deck conditions, foundation conditions, approach conditions, foundation scour, and spalling concrete.

Table 6-6. Bridges Inspection Rating Descriptions

Inspection Categories	Rating and Description
Deck Conditions, Foundation Conditions, Approach Conditions, Foundation Scour, and Spalling Concrete	1. Bridge is excellent condition. No visual inadequacies noted.
	2. Bridge has areas of minor cosmetic inadequacies; however, it appears to be in good working condition.
	3. Bridge is in fair condition. The bridge has minor observable inadequacies; however, it remains in good working condition.
	4. Bridge is in need of repair. The bridge condition does not pose an immediate hazard to the public.
	5. Bridge needs immediate repairs. The bridge condition poses an immediate hazard to the public.

6.3.2 Limitations of Status Evaluations

As mentioned, DWR only maintains and inspects the bridges shown in Figure 6-10 in accordance with California Water Code Section 8361 (c). DWR does not maintain or inspect any bridges in the San Joaquin River watershed. Reported conditions are limited to items that can be visually inspected annually during summer, and does not involve additional testing by DWR. Status information for other bridges in the flood management system is not included because it was not available.

6.3.3 Results of Status Evaluations

Bridge conditions noted from the DWR Bridge Inspection Program are presented on Figure 6-10 for the Sacramento River watershed. Detailed description, of the DWR inspections can be found in the DWR *Annual Bridge Inspection Report* (2009c).

Of the 10 bridges inspected by DWR, 2 had ratings of 4 and 5 overall, and were noted as needing repairs. Since 2000, three Sutter Basin bridges (not inspected by DWR or depicted in Figure 6-10) have been replaced and turned over to Sutter County for future O&M.

Ongoing and planned remedial actions and ongoing actions to improve future evaluations are summarized in Appendix C, Section C-3.

Figure 6-10. Bridge Conditions in Sacramento River Watershed

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7.0 Approach for SPFC Improvements

Sections 4.0, 5.0, and 6.0 of the FCSSR describe physical conditions of SPFC levees, channels, and flood control structures based on best available information. In some areas of the Sacramento and San Joaquin watersheds, not enough information is available at this time to determine whether SPFC facilities are performing to their expected level. While some SPFC facilities meet their intended performance standards, many do not, show visible distress, or otherwise have problems that could impair how the facilities function. These problems likely increase the chances that facilities could fail and contribute to major flooding.

DWR has plans and programs to further evaluate SPFC facility performance, identify needed flood system reconstructions and improvements, and implement reconstructions and improvements as State, federal, and local funding becomes available. These include ongoing programs under the FloodSAFE initiative and as part of long-term Central Valley Flood Protection Plan implementation. This section provides an overview of DWR's systematic approach for addressing problems with flood management facilities and for taking actions to improve performance of the SPFC.

7.1 FloodSAFE California

In January 2005, the governor drew attention to the State's flood problems, calling for improved maintenance, system rehabilitation, effective emergency response, and sustainable funding. In a white paper entitled *Flood Warnings: Responding to California's Flood Crisis* (DWR, 2005), DWR outlined flood challenges California faces and offered specific recommendations for administrative action and legislative changes.

An important result of the white paper was the creation of DWR's FloodSAFE California (FloodSAFE) in 2006, a multifaceted initiative to improve integrated flood management. Most of the funds currently available to help implement FloodSAFE are provided by Propositions 1E and 84. The vast majority of funds currently available for flood system improvements were allocated for the Central Valley and for the SPFC. Work to improve and rehabilitate SPFC flood management facilities intensified after passage of Propositions 1E and 84 in 2007, and included

emergency repairs, urban levee improvements, and early implementation projects in the Central Valley.

FloodSAFE seeks to improve all aspects of integrated flood management. Because SPFC improvements will occur incrementally over decades, FloodSAFE must be flexible and program organization periodically updated based on new information and changing conditions. DWR has expanded its ongoing core programs and added new programs to cover all near-term and long-term activities needed for SPFC improvement.

7.2 Central Valley Flood Protection Plan

A critically important component of FloodSAFE work is the CVFPP. The CVFPP is the primary vehicle for addressing problems identified in this FCSSR, and further improvements to the SPFC. It is highlighted again in this section because the CVFPP addresses how to correct, improve, and manage the SPFC.DWR is required to prepare the CVFPP by January 1, 2012, for adoption by the Board by July 1, 2012. The plan will be updated every 5 years thereafter (in years ending in 7 and 2). As the first edition of this long-term planning document, the 2012 CVFPP will guide State investments for improving integrated flood management in the Sacramento-San Joaquin Valley. It is being produced in coordination with federal, regional, local, and tribal entities, and other interested parties and will guide many subsequent implementation activities.

The CVFPP represents a sustainable, integrated flood management plan that will guide State, federal, and local actions to improve flood management in this vital region of the State. To adequately address current and increasing future demands on the SPFC, significant and sustained actions are needed to improve the performance level of SPFC facilities that exist today. Implementing a program of actions to address identified problems as part of a systemwide approach to improving flood management throughout the Sacramento and San Joaquin river watersheds will take many years and significant coordination between local, State, and federal governments.

The CVFPP describes a recommended implementation approach that considers the sequential phasing of projects. Sequential phasing will allow an initial focus on the most urgent flood system needs, provide time needed to establish a firm foundation to further develop and implement actions in subsequent phases, and allow for the establishment of a sound funding strategy to pursue future additions to effective flood management in the Central Valley.

A wide range of actions will be required to develop, construct, and manage improvements to the SPFC. This work will be organized into several programs, established and led by DWR and implemented in coordination with local and federal partners. These programs are managed by DWR's existing FloodSAFE organization. Each program will be responsible for specialized implementation. Together, the programs cover all work required for implementation and management of the improved SPFC. DWR's major flood management programs are as follows:

- Flood Emergency Response Program
- Flood System Operations and Maintenance Program
- Floodplain Risk Management Program
- Flood Risk Reduction Projects Program
- Flood System Assessment, Engineering, Feasibility, and Permitting Program

The first three programs are responsible for residual risk management. The fourth program is responsible for implementing on-the-ground projects for SPFC improvement. The last program is responsible for conducting feasibility evaluations, design, engineering, and other activities necessary for implementation.

As described in Section 1.1, the *State Plan of Flood Control Descriptive Document* (DWR, 2010a) and this FCSSR are two important documents contributing to the CVFPP.

The Central Valley Integrated Flood Management Study, which is being led by USACE, is the federal complement to the CVFPP and focuses on shared opportunities to reduce flood risk in the Central Valley in an integrated water resource and flood management context. Both studies have the common goal of determining a State-federal strategy that will lead to expedient and cost-shared implementation of new and continuing projects to reduce flood risk in the Central Valley. USACE participated in CVFPP development, providing valuable input on all phases of the plan, producing joint data and technical information, and assisting in use of analytical tools. USACE is also providing technical expertise in developing flood hydrology, analyzing reservoir operations, and incorporating risk-based decision-making processes that improve system reliability.

In summary, DWR has plans and programs to further evaluate the status of facility performance, identify needed flood system improvements, and implement those improvements as State, federal, and local funding becomes available. The CVFPP, in particular, will guide improvement and management of the SPFC in the future.

8.0 Findings and Recommendations

This section summarizes major finding and recommendations of the FCSSR for use in the CVFPP.

8.1 Findings

The flood management system has provided tremendous benefits to public safety and protection of property in the Central Valley – as mentioned, the system has prevented many billions of dollars in flood damages since facilities were originally constructed. However, today, the system is being relied on to provide flood protection and other benefits at levels that were not envisioned when the system was constructed. When evaluated against modern engineering and safety criteria, some SFPC facilities face a higher chance for failure during a flood event than other facilities.

The SPFC includes approximately 1,600 miles of levees and approximately 2,600 miles of channels. DWR's Levee Evaluations Program has evaluated approximately 1,530 miles[1] of levee included in the SPFC. Of the SPFC levees evaluated by the Levee Evaluations Program, about 300 miles help protect urban areas and about 1,230 miles help protect nonurban areas. Associated with the SPFC levees are about 420 miles of non-SPFC levees (120 miles of urban and 300 miles of nonurban levees) that are instrumental to effective functioning of the SPFC. Information from the *State Plan of Flood Control Existing Channel Capacity Assessment Technical Memorandum* (CVFED, 2009), supplemented with project-specific modeling results, supported evaluation of 1,016 miles of approximately 2,600 miles of SPFC channels. The overall condition of urban levees, nonurban levees, channels, and flood control structures of the SPFC can be summarized as follows:

- **Urban levees** – Approximately half of about 300 miles[2] of SPFC urban levees evaluated do not meet current levee freeboard, stability, or seepage design criteria[3] at the design water surface elevation.

[1] An additional 13 miles of SPFC urban levees are being evaluated, and results will be included in future updates.
[2] An additional 13 miles of SPFC urban levees are being evaluated, and results will be included in future updates.
[3] The design criteria used were based on USACE 2000 *Design and Construction of Levees Engineering Manual 1110-2-1913* and DWR 2010 *Interim Levee Design Criteria for Urban and Urbanizing Areas in the Sacramento Valley, Version 4*.

- **Nonurban levees** – Approximately three-fifths of about 1,230 miles of SPFC nonurban levees evaluated have a high potential for failure from under-seepage, through-seepage, structural instability, and/or erosion at the assessment water surface elevation.[4] Nonurban levees were evaluated based on systematic, consistent, repeatable analyses that correlated geotechnical data with levee performance history, not relative to any current design criteria.[5]

- **SPFC channels** – Approximately half of the 1,016 miles of channels evaluated in the SPFC have a potentially inadequate capacity to convey design flows, and require additional evaluation to confirm conditions.

- **SPFC flood control structures** – None of the 32 hydraulic structures or 11 pumping plants inspected by DWR for the SPFC were rated Unacceptable during the 2009 inspections. Of the 10 SPFC bridges inspected by DWR in 2009, 2 were in need of repairs.

Many potential factors can influence levee performance – the threats these factors pose are not all equal. Table 8-1 lists factors that influence facility performance, findings related to each factor, and the relative threat posed by the factor. The relative threat posed by each factor is a subjective representation of the prevalence of the factor and the degree to which the presence of that factor would contribute to potential facility failure. Factors identified as a “high” relative threat to SPFC facilities generally are the most prevalent and/or greatly contribute to potential facility failure. Those identified as a “low” relative threat to SPFC facilities generally are the least prevalent and/or contribute less to potential facility failure. Likewise, factors identified as a "medium" relative threat to SPFC facilities are moderately prevalent and/or contribute moderately to potential facility failure. Therefore, the relative threat posed by each factor is subjective in nature and serves only to help identify and prioritize the factors most likely to contribute to SPFC facility failure. However, prioritizing relative threats affecting SPFC facilities does not necessarily translate directly into investment priorities. To decide which levels of investment are prudent for repairs or improvements, economic and life safety consequences associated with potential failure must also be considered. Potential consequences of

[4] Where available, 1955/57 design water surface elevations were used as the assessment water surface elevation. In the absence of 1955/57 design water surface elevations, the assessment water surface elevation was based on freeboard requirements for each levee segment (i.e., generally 3 feet below the levee crest).

[5] This approach was selected because the extent of the NULE Project is significantly greater than the ULE Project, making it difficult to conduct the same level of field explorations and geotechnical data collection performed for ULE levees.

facility failure are not presented in this report; they are evaluated in the CVFPP.

Table 8-1. Summary of Flood Control System Status Report Findings

	Factors	Findings	Relative Threat Posed by Factor[1]
Levees	**Overall Levee Condition (multiple factors)**	• Approximately half of SPFC urban levees do not meet current levee freeboard, stability, or seepage design criteria at the design water surface elevation. • Approximately three-fifths of SPFC nonurban levees have a high potential for levee failure from under-seepage, through-seepage, structural instability, and/or erosion at the assessment water surface elevation.	N/A
	Levee Geometry Check	• Approximately one-third of SPFC urban levees deviate from current standard levee design prism criteria. • Levee geometry deviates significantly from the standard levee design prism for some nonurban SPFC levees.	Medium
	Seepage	• Approximately one-third of SPFC urban levees do not meet current seepage design criteria. • Almost half of SPFC nonurban levees have a high potential for levee failure from under-seepage. • Approximately one-quarter of SPFC nonurban levees have a high potential for levee failure from through-seepage.	High
	Structural Instability	• Approximately one-fifth of SPFC urban levees do not meet current structural stability design criteria. • Approximately one-eighth of SPFC nonurban levees evaluated in the Sacramento River watershed and 1 percent in the San Joaquin River watershed have a high potential for levee failure from structural instability.	Medium
	Erosion	• Erosion assessments for urban levees are underway, and results are not available at this time. • Almost one-seventh of SPFC nonurban levees have a high potential for levee failure from erosion.	Medium
	Settlement	• Four known localized levee locations have settlement (localized depressions) that endangers the integrity of the SPFC levees. [5]	Low
	Penetrations[2]	• More than 6,000 penetration sites are documented in SPFC levees, and many more remain undocumented.	Medium
	Levee Vegetation	• About 15 miles of SPFC levees are noncompliant with the 2007 DWR *Interim Levee Vegetation Criteria*.[3] [5]	Low
	Rodent Damage	• More than one-third of the 1,459 miles of SPFC levees studied had at least eight reported occurrences of burrowing activity over a 21-year study span.	Medium
	Encroach-ments[4]	• 1,223 encroachment sites were identified as partially or completely obstructing visibility and access to the levee and/or within 10 feet of the landside toe.[5]	Medium

Table 8-1. Summary of Flood Control System Status Report Findings (contd.)

	Factors	Findings	Relative Threat Posed by Factor[1]
Channels	**Inadequate Conveyance Capacity**	• Approximately half of the 1,016 miles of SPFC channels evaluated are potentially inadequate to convey design flows, and require additional evaluation to confirm conditions. • Approximately one-quarter of channel design capacities reported in O&M manuals do not agree with flows specified in the design profiles.	Medium
	Channel Vegetation	• Of 186 miles of SPFC channels inspected by DWR, 1 location was rated Unacceptable and 54 locations were rated Minimally Acceptable because of vegetation and obstructions.[5]	Low
	Channel Sedimentation	• Of 186 miles of SPFC channels inspected by DWR, 1 location was rated Unacceptable and 23 locations were rated Minimally Acceptable because of shoaling/sedimentation.[5]	Low
Structures	**Inadequate Hydraulic Structures**	• Of 32 SPFC hydraulic structures inspected by DWR, no structures were rated Unacceptable because of structural, vegetation/obstruction, encroachment, or erosion/sedimentation issues.[5]	Low
	Inadequate Pumping Plants	• Of 11 SPFC pumping plants inspected by DWR, none were rated Unacceptable.[5]	Low
	Inadequate Bridges	• Of 10 SPFC bridges inspected by DWR, 2 were in need of repairs.[5]	Low

Note:
[1] The relative threats listed in Table 8-1 were generated based on professional experience of technical staff from DWR and partner agencies.
[2] Penetrations include man-made objects that cross through or under a levee or floodwall and have the potential to provide a preferential seepage path or hydraulic connection with the waterside. Typically, a penetration is a pipe or transportation structure, such as a roadway or rail line.
[3] This finding is based on DWR 2007 *Interim Levee Vegetation Criteria* and not on USACE levee vegetation criteria. Comparison with USACE levee vegetation criteria would show more SPFC levees as noncompliant.
[4] Encroachments are any obstruction or physical intrusion by construction of works or devices, planting or removal of vegetation, or caused by any other means, for any purpose, into a flood control project, waterway area of the flood control project, or area covered by an adopted plan of flood control (California Code of Regulations Title 23 Chapter 1 Article 2 Section 4 (m)). Encroachments include boat docks, ramps, bridges, sand and gravel mining, placement of fill, fences, retaining walls, pump stations, residential structures, and irrigation and landscaping materials/facilities.
[5] Inspection results reported are from DWR's 2009 Inspections.

Key:
DWR = California Department of Water Resources
N/A = Not applicable
O&M = operations and maintenance
SPFC = State Plan of Flood Control
USACE = U.S. Army Corps of Engineers

The findings in Table 8-1 are relative to DWR's current criteria for use in the CVFPP. In most cases, these criteria are identical, or very similar to USACE criteria. However, differences between DWR and USACE levee

vegetation criteria are significant enough that comparison of levees with USACE criteria would likely show more SPFC levees as noncompliant with current USACE criteria. As noted in Section 4.7, DWR and USACE continue to work to resolve these differences.

To adequately address current and increasing future demands on the SPFC, significant and sustained actions are needed to improve the performance level of SPFC facilities that exists today. This will include continued efforts at the State, federal, regional, and local levels to assess and evaluate programs and policies affecting the SPFC and conditions of non-SPFC facilities that affect performance of the flood control system. Implementing an appropriate collection of management actions in a systemwide approach to address identified problems properly, and to improve the conditions of flood management throughout the Sacramento and San Joaquin river watersheds will take many years. It is important to recognize that improvements to the SPFC will be costly and require the active involvement of State, federal, regional, and local interests. Significant amounts of funding will be needed for future project planning, development, implementation by USACE and the State, and for O&M primarily by maintaining agencies.

Local communities (both urban and nonurban) will require significant financial and technical assistance from the State and federal governments over the next 20 to 25 years to take appropriate actions to improve the current condition of SPFC facilities. FCSSR findings provide important input on system conditions for the CVFPP. As mentioned, the CVFPP will guide future State investments through incremental projects to address identified problems in the SPFC.

8.2 Recommendations

As mentioned, California Water Code Section 9120 directs that the FCSSR is to include appropriate recommendations regarding SPFC levees and future work activities. Recommendations regarding potential modifications to the SPFC will be included in the 2012 CVFPP. Recommendations regarding future work activities considered important to support future efforts as part of the CVFPP include the following:

- Pursue Board adoption of the findings of this FCSSR, as required by California Water Code Section 9120, and support the Board in communicating FCSSR recommendations to the California Legislature.

- Per California Water Code Section 9120(a), Continue to work with State, federal, regional, and local agencies to create a broadly supported

CVFPP to guide long-term investments related to the SPFC over the next several decades.

- Build on and improve existing partnerships with federal, regional, and local agencies to develop site-specific actions for the SPFC that are consistent with the integrated, systemwide approach developed in the CVFPP.

- Continue to partner with agencies, and form new partnerships, to conduct special studies to improve understanding of the various factors that present threats to SPFC facilities. These studies include continued efforts to research the impacts of levee vegetation, assess locations and importance of levee penetrations, characterize the probability of levee failure, and other technical studies.

- Proceed with multiagency work efforts to further evaluate facility status, identify needed flood system reconstructions and improvements, and implement them, as State, federal, and local funding becomes available.

- Continue to improve data sharing and accessibility of annual inspection results for partner agencies and the public.

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10.0 Acronyms and Abbreviations

Board	Central Valley Flood Protection Board
CVFED	Central Valley Floodplain Evaluation and Delineation
CVFPP	Central Valley Flood Protection Plan
DFG	California Department of Fish and Game
DWR	California Department of Water Resources
EC	Engineering Circular
EM	Engineering Manual
FCSSR	Flood Control System Status Report
FEMA	Federal Emergency Management Agency
FloodSAFE	FloodSAFE California
FMO	DWR Flood Maintenance Office
GIS	geographic information system
LiDAR	light detection and ranging
NULE	Non-Urban Levee Evaluations
O&M	operations and maintenance
SPFC	State Plan of Flood Control
State	State of California
ULE	Urban Levee Evaluations
USACE	U.S. Army Corps of Engineers

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